

# **Opportunities for the Early Production of Fischer-Tropsch (F-T) Fuels in the U.S. -- An Overview**

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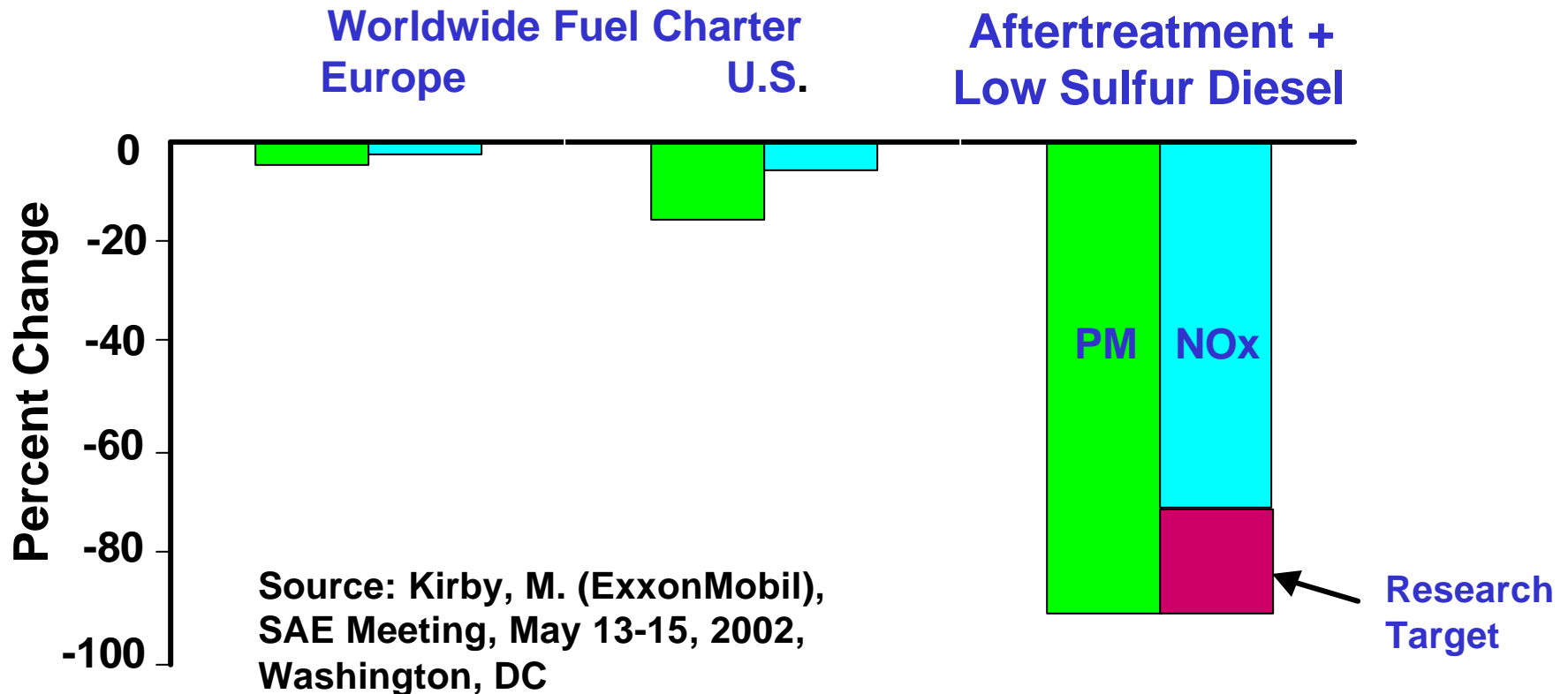
**2002 DEER Workshop**

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# Outline of Presentation

- **Background**
- **Fischer-Tropsch (F-T) Fuels from Natural Gas**
  - DOE Ultra Clean Transportation Fuels Initiative (Conoco; ICRC/Syntroleum/Marathon Oil)
- **F-T Fuels from Heavy Hydrocarbons**
  - DOE Early Entrance Coproduction Plant Initiative (Texaco; WMPI)
- **F-T Fuel Costs & Early Production Opportunities**
- **Conclusions**

# Aftertreatment Enabled By Low Sulfur Fuels



- Full Diesel Potential Cannot Be Reached Via Fuel Composition Changes
- NOx Presents a Major Technical Challenge

# Ultra Low Sulfur Diesel Fuel versus Fischer-Tropsch Diesel

- **Ultra Low Sulfur Diesel (ULSD) (15 ppm maximum sulfur)**
  - To be Phased In Beginning in 2006
  - What Is In the Future??
- **Fischer-Tropsch (F-T) Diesel**
  - Attributes: Zero Sulfur and Zero Aromatics; Cetane Number > 70; Lower Heating Value; Lower Lubricity
  - Prudent Assumption: No Premium Over ULSD
  - Domestic Production of F-T Diesel – A Tough Challenge

# **Fischer-Tropsch (F-T) Fuel Production Technologies: Current Status**

- **Commercial F-T Fuel Plants In Operation**
  - Natural Gas Feedstock: Shell (Malaysia), Mossgas (S. Africa)
  - Coal Feedstock: Sasol (S. Africa)
  - A 3-Step Process: Feedstock to Syngas (CO & H<sub>2</sub>), Syngas Conversion to F-T Crude, & Products Upgrading
- **Advanced F-T Fuel Technologies Under Development**
  - Natural Gas Feedstock: Active Industrial Interests
    - Monetize Stranded Gas Reserves
  - Heavy Hydrocarbons: Coproduction Strategy
    - Coproduce F-T Fuels with Electricity, Chemicals, Steam, ..
    - DOE-Industry Partnerships

# Hurdles for Commercial Fischer-Tropsch (F-T) Fuels Production – A Partial List

- **High Capital Costs**
  - Continued R&D On Syngas (CO & H<sub>2</sub>) Production\*\*
- **Operating Complexity**
  - Commercial-Scale Demonstration of Integrated Sub-Systems\*\*
- **Market Risks**
  - Oil Price (Absolute & Volatility)
  - Customer Acceptance: Fleet Operational & Maintenance Data Base with F-T Fuels\*\*
- **Environmental Issues**
  - Greenhouse Gases\*\*

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\*\* DOE Supported R&D Activities

# F-T Fuels from **Natural Gas**

## -- New Commercial Demo Plants in U.S.

<u>Company</u>	<u>Location</u>	<u>Capacity</u>	<u>Status</u>
<b>Conoco</b>	Ponca City, OK (Next to Refinery)	400 b/d (F-T Fuels)	Startup 2003
<b>Syntroleum</b>	Tulsa, OK (Stand Alone)	70 b/d (F-T Fuels)	Startup 2003
<b>BP</b>	Nikiski, AK (Close to Refinery)	300 b/d	Startup 2002

# Conoco Gas-to-Liquids (GTL) Technology– Natural Gas Feedstock

- **400 b/d Commercial Demo Plant (Self-Funded)**
  - Under Construction & Startup Scheduled for 2003
  - 3-Year Operation In F-T Mode Planned
  - Product Marketing Director Appointed
  - Participation In Clean Cities Program Under Consideration
    - Operational & Maintenance Data Base
- **Commercial Size GTL Plants**
  - Stranded Gas Reserves (Fields of 5 Trillion Cubic Feet (TCF) or Larger to Keep A 60,000 b/d Plant Full for 25 Years)
  - > 60,000 b/d

# **DOE-Conoco Cooperative Agreement: Evaluation of Ultra Clean Fuels from Natural Gas - Tasks1 & 2**

**Subcontractor: Nexant, Inc.**

- **Task 1: Life-Cycle Assessment (LCA) – A Well to Wheel Analysis**
  - **Transportation & Power; Peer-Reviewed**
  - **Life Cycle Inventory & Life Cycle Impact Assessment**
  - **Feedstocks: Crude, Natural Gas, Corn, Biomass**
  - **Energy Use, Greenhouse Gases & Criteria Air Pollutants**
  - **Draft Report Scheduled for Release by Jan 2003**
- **Task 2: Ultra Clean Fuels Market Assessment**
  - **F-T Fuels: Supply, Demand, & Pricing Issues in U.S. Relative to Competing Petroleum-Based & Other Alternative Clean Fuels; Feedstocks for Chemicals**
  - **Methanol: Infrastructure Issues**
- **Time Frame: Current, 2006, & 2015**

# **DOE Cooperative Agreement with Conoco (Continued) – Task 3: Fuel, Engine, & Fuel Cell Testing (Jul 01-Nov 03)**

## **Subcontractor: Pennsylvania State University**

- **Compression Ignition Engine Studies**
  - **Members: Cummins; Johnson-Matthey**
  - **Participant: Engelhard**
  - **Cummins ISB MY2000, 5.9L, 215/235 hp, Turbodiesel**
    - **Emission Monitoring: PM, NOx, HC, CO**
    - **Aftertreatment: CRT/NOx Adsorber; DPF/Urea-SCR**
  - **Fuel Formulation Effects :**
    - **Petroleum Diesel, Conoco F-T Diesel & Oxygenate (Biodiesel)**
- **PEM Fuel Cell Testing**
  - **Compare Indirect & Direct Methanol Fuel Cell Systems**
  - **Methanol Reformer Development**
  - **Transportation & Electric Power Applications**

# **Syntroleum Gas-to-Liquids (GTL) Technology Development**

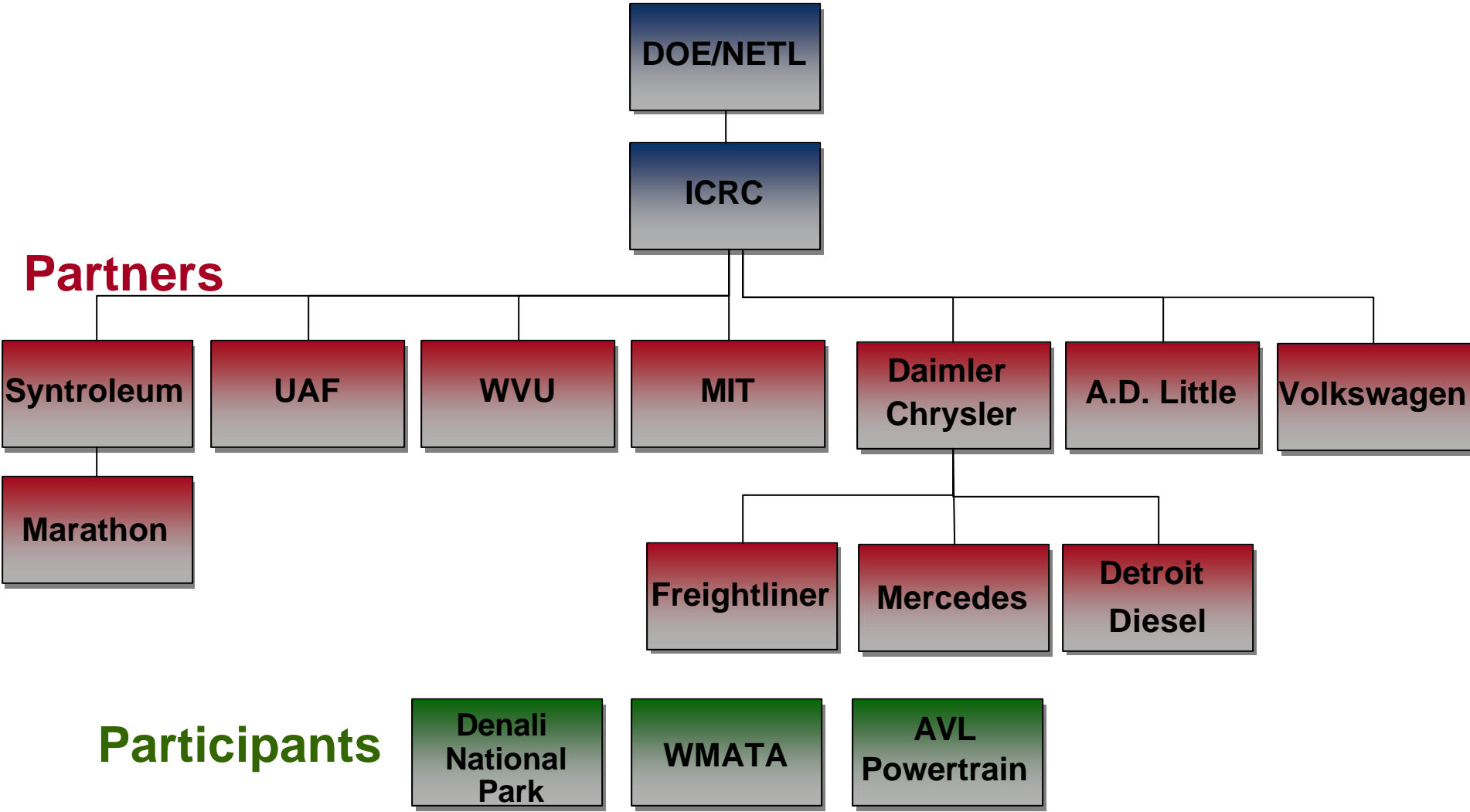
## **Commercial Demo Plant**

- **70 b/d Plant Erected in ARCO Refinery in Washington State & Operated from April 1999 to July 2000**
- **Produced F-T Synthetic Crude (C<sub>5</sub>+) from Natural Gas Feedstock**
- **Mobile & Modular Units**

## **Scaleup Beyond Commercial Demo Plant**

- **Small Footprint Plants (SFP) (1,000 – 5,000 b/d)**
- **Large Commercial Plants (5,000 – 180,000 b/d)**

# DOE-ICRC/Syntroleum/Marathon Oil Cooperative Agreement -- Partner & Participant Organizations



# DOE–ICRC/Syntroleum/Marathon Oil Cooperative Agreement: Gas-to-Liquids (GTL) Fuels Production & Demonstration

Prime Contractor: Integrated Concepts & Research Corp. (ICRC)

- Fuels Production Team: **Syntroleum\*\***, & Marathon Oil
- Engine Team: **ICRC\*\***, **AVL Powertrain\***, MIT, DaimlerChrysler, & Volkswagen
  - F-T Fuels In Advanced Prototype Diesel Engines
- Fleet Team: **ICRC Team Leader**
  - Fleet Tests (**WMATA\***, **Denali National Park\***)
  - Emission Testing (West Virginia U.)
  - Small Footprint Plant (SFP) Feasibility & SFP Fuel Applications in Alaska (U. of Alaska at Fairbanks)
- Market Team: **Consultant\*\***, A.D. Little, & Syntroleum
  - Economic Analysis

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**\*\* Team Leader      \* Participants**

## **DOE–ICRC/Syntroleum/Marathon Oil Cooperative Agreement (Continued) – 70 b/d F-T Fuel Small Footprint Plant (SFP)**

- **Natural Gas Feedstock**
- **Location: Port of Catoosa, Oklahoma (Near Tulsa)**
- **Use Equipment from Demo Plant in ARCO Refinery in WA**
- **Add F-T Syncrude Upgrading Step & Gas Turbine**
- **Under Construction & Startup/Operation In 2003**
  - **Operation Plan to Include F-T Jet Fuel Production**
- **Negotiations Underway Between Syntroleum & DOD for F-T Jet Fuel Production & Testing**
- **Unit On Standby After DOE Contract**

# **DOE–ICRC/Syntroleum/Marathon Oil Cooperative Agreement (Continued) – F-T Fuel Fleet Tests**

- **Participants:**
  - Washington (DC) Metro Area Transit Authority (WMATA)
  - Denali National Park, Alaska (Denali)
- **Scope of Tests**
  - Neat SFP F-T Diesel (Up to 24,000 gallons at Each Site)
    - Operational & Maintenance Data; Exhaust Emission Analysis
    - Benchmark: Low Sulfur Conventional Diesel
  - Test Period
    - Denali (May - September 2004)
    - WMATA (October 2003 to May 2004) – Different Seasons
  - WMATA: Single Engine Brand Fitted with PM Traps
  - Dynamometer Durability Tests to Precede Fleet Tests

# **F-T Fuels from Heavy Hydrocarbon Feedstocks**

- **Feedstocks: Coal, Petroleum Coke, & Biomass**
- **Technology Development Status**
  - **Coproduction Strategy (IGCC + F-T Synthesis)**
    - **IGCC (Integrated Gasification & Combined Cycle) to Produce Power, A Leading Clean Coal Power Technology**
    - **Coproduce Electricity, F-T Fuels, Steam, Chemicals & H<sub>2</sub>**
    - **Higher Process Efficiency**
    - **Next Step: Commercial Demo of Integrated Sub-Systems**
- **DOE Early Entrance Coproduction Plant (EECP) Initiative**
  - **Feasibility Studies for Projects Adjacent to Existing Infrastructures, Carried Out In 3 Phases**
  - **Deliverable: Preliminary Engineering Design & Preliminary Project Financing Plan**

# **Texaco-DOE Cooperative Agreement – Early Entrance Coproduction Plant (EECP)**

- **Subcontractors: Kellogg Brown & Root, General Electric, Praxair & Rentech**
- **Phase 1: Concept Definition & RD&T Planning (Completed)**
  - **Location: Adjacent to Motiva Refinery in Port Arthur, TX**
  - **Feedstock: Petroleum Coke @ 1235 Short Tons/Day**
  - **Finished Wax Case Has Most Favorable Financial Return**
    - **457 b/d Wax, 125 b/d Diesel, 35 b/d Naphtha, 55 MW Power, Steam & Sulfur**
    - **12% Internal Rate of Return: Zero Cost for Feedstock**
- **Phase 2: Research, Development & Testing (Underway)**
  - **Process R&D; Engine/Fuels Testing; Gas Turbine Tests**
- **Search for New Project Site Due to Chevron/Texaco Merger (Pending)**
- **Phase 3: Preliminary Engineering Design (Pending)**

# **Waste Management Processors Inc. (WMPI)-DOE Cooperative Agreement – Early Entrance Coproduct Plant (EECP)**

- **Sub-Contractors: Texaco, Sasol Technology Ltd., & Nexant, Inc.**
- **Phase 1: Project Feasibility Study (Underway)**
  - **Location: Gilberton, PA (Adjacent to Coal Power Station)**
  - **Feedstock: Anthracite Coal Waste**
  - **Products Slate: 5,000 b/d F-T Fuels, 35 MW Electric Power, Steam & Sulfur**
- **Phase 2: R&D/Testing (Pending)**
  - **Feasibility Testing of Anthracite Coal Waste in Gasifier**
- **Phase 3: Preliminary Engineering Design (Pending)**

# Unit Cost of Production (\$/Barrel)

	<b>GTL</b>	<b>Refinery</b>
<b>Natural Gas (@ \$.50/MMBtu)</b>	<b>\$ 4.00</b>	
<b>Crude Oil (@ \$17/Bbl)</b>		<b>\$17.00</b>
<b>Operating Costs</b>	<b><u>3.00</u></b>	<b><u>2.50</u></b>
<b>Cash Costs</b>	<b>7.00</b>	<b>19.50</b>
<b>Capital Recovery, Taxes</b>	<b><u>12.00</u></b>	<b><u>6.50</u></b>
<b>Total Cost to Produce</b>	<b>\$19.00</b>	<b>\$26.00</b>

Source: J. L. Rockwell (Conoco),  
CWC 2<sup>nd</sup> Annual Global Summit,  
May 28-30, 2002, London, UK

# **Opportunities for Early Commercial Production of F-T Diesel in U.S.**

- **Natural Gas Feedstock: Dedicated F-T Fuels Plants**
  - **Stranded Gas In Alaska North Slope (Low Gas Price)**
  - **Sub-Quality Natural Gas: Syntroleum SFP Applications**
- **Heavy Hydrocarbon Feedstock: Coproduction Plants**
  - **Site-Specific Projects**
    - **High Sulfur Petroleum Coke with Zero or Negative Costs**
    - **Other Environmentally Disadvantageous Feedstocks**
  - **DOE Clean Coal Power Initiative (CCPI) Solicitation**
    - **10 Year, \$2 Billion Program (DOE Share)**
      - **Requires >50% Cost Sharing**
    - **Feedstock: >75% of Heating Value from Coal**
    - **Coproduction Mode Allowed**
    - **Round 1 Solicitation Underway**

# **Opportunities for Early Commercial Production of F-T Diesel (Continued)**

- **Prospects of Early F-T Fuels Production Could Be Improved with Assistances**
  - **Encourage Early F-T Fuels Use**
    - **Energy Policy Act of 1992 (EPAAct)**
      - **Wider Use of Alternative Fuels In Alternative Fuel Vehicle (AFV) Fleets**
    - **DOD Interests In Using F-T Fuels in Advanced Propulsion System (Joint Work between Air Force & DOE/NETL)**
  - **Financial Incentives To Nurture New Alternative Clean Fuel Technologies**
    - **Pennsylvania S.B. 650 Coal Waste Removal & Ultra Clean Fuels Tax Credit Enacted In 1999**
      - **Capped at \$47 Million**

# Conclusions

- **Successful Startup & Operation of the 3 Commercial Demo Plants Beginning In 2002 Could Mark the Beginning to Make Domestically Produced F-T Fuels Available for Commercial Applications.**
- **Planned Fleet Tests Should Yield An Extensive Operating & Maintenance Data Base for F-T Diesel Applications**
- **Results of EECF Feasibility Study Appears Encouraging with Project Sited Next to Refinery and Using High Sulfur Petroleum Coke as Feedstock.**
- **Early Domestic Production of F-T Fuels Could Be with Stranded Gas Reserves or in Site-Specific Projects In Coproduction Mode with Coal and/or Petroleum Coke as Feedstocks**
- **Prospects of Early Domestic F-T Fuels Production Could Be Improved with Assistances Including Wider Use of F-T Fuels in AFV fleets under EPAct, and Financial Incentives with Capped Limit.**